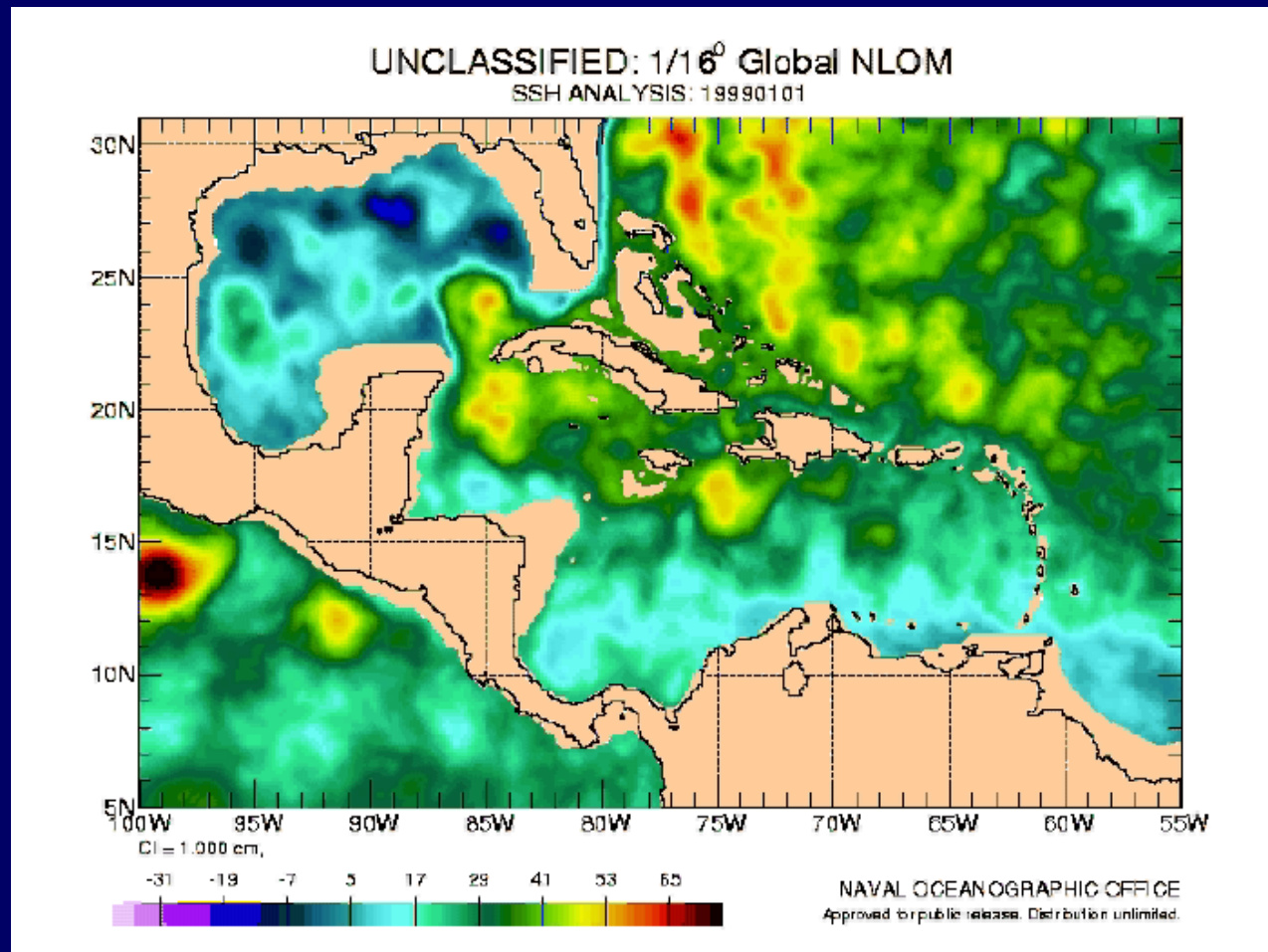


Advances in Modeling the Intra-Americas Sea

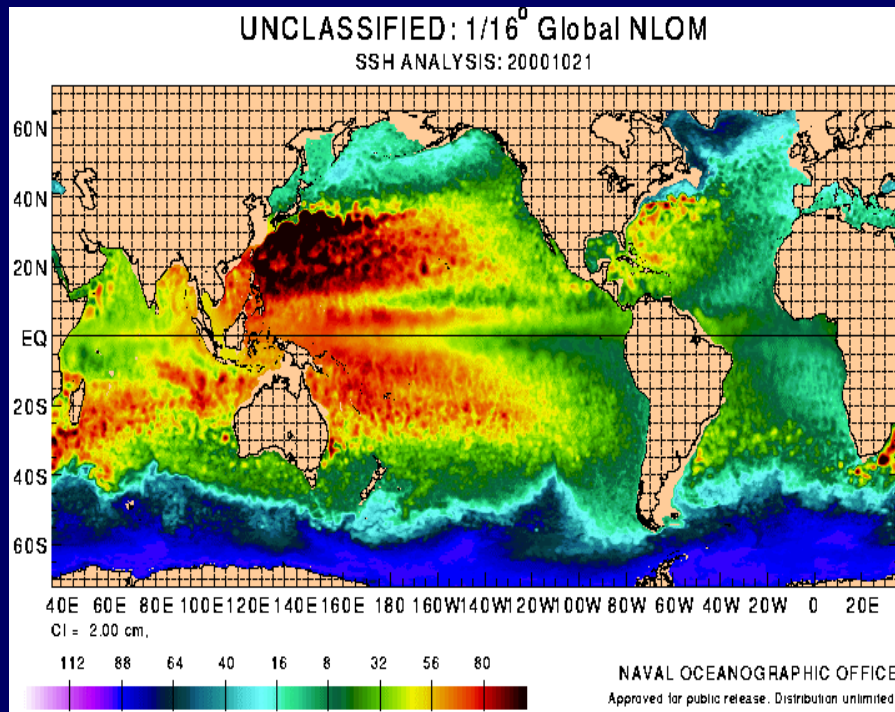
T.L. Townsend, H.E. Hurlburt and A.J. Wallcraft
Naval Research Laboratory, Stennis Space Center, MS



OCEANS 2002 MTS/IEEE, Biloxi, MS, 28-31 October 2002

NRL Layered Ocean Model (NLOM)

1st Generation Operational Global Navy Model



Global primitive
equation ocean
circulation model

7 layers (including ML)

Forced by real-time
NOGAPS surface
heat fluxes and wind
stresses

Assimilates satellite
altimeter data and
MODAS SST analysis

Excludes Arctic and
coastal regions

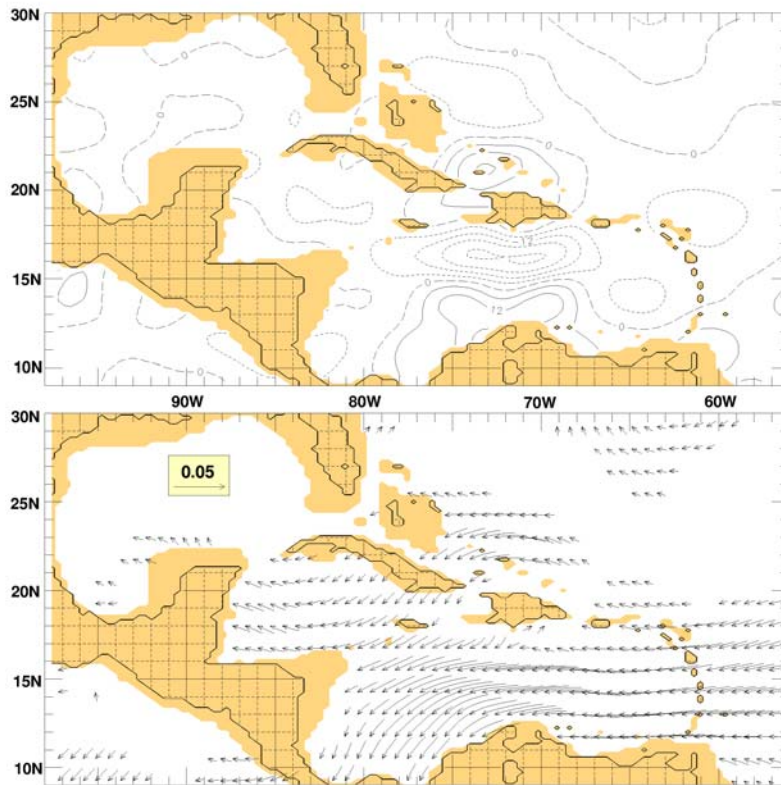
Real-Time results (updated daily)

http://www7320.nrlssc.navy.mil/global_nlom/globalnlom/skill.html

Intra-Decadal Variability in the IAS

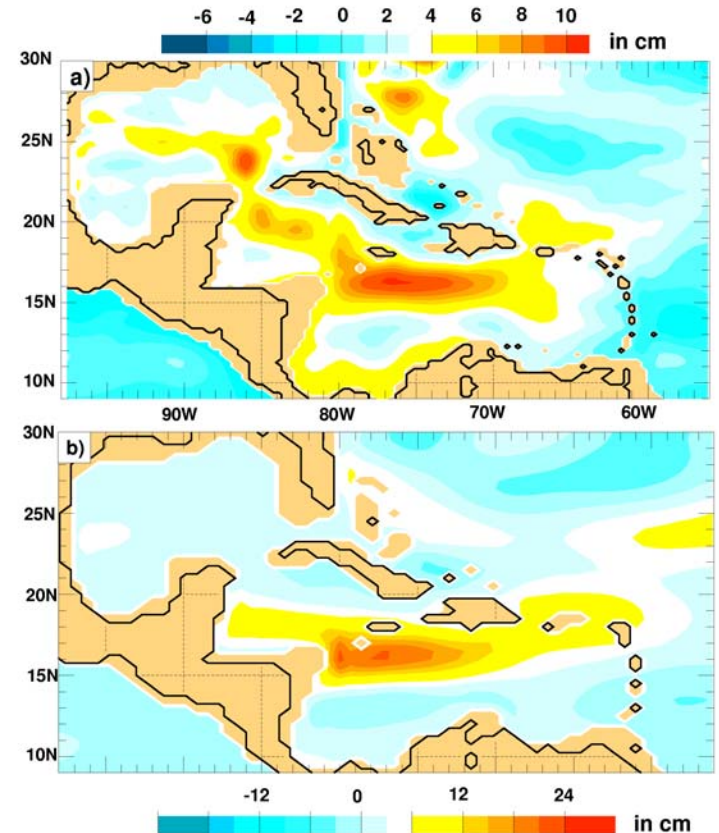
An intradecadal anomaly in the ECMWF wind forcing over the Caribbean as seen in the wind stress curl (top panel) and the wind stress vectors (bottom panel).

1985-1986 Mean minus 1981-1991 Mean



Wind Curl contour interval is $6 \text{ Pa/m} \times 10^{-8}$, wind stress in newtons/m²

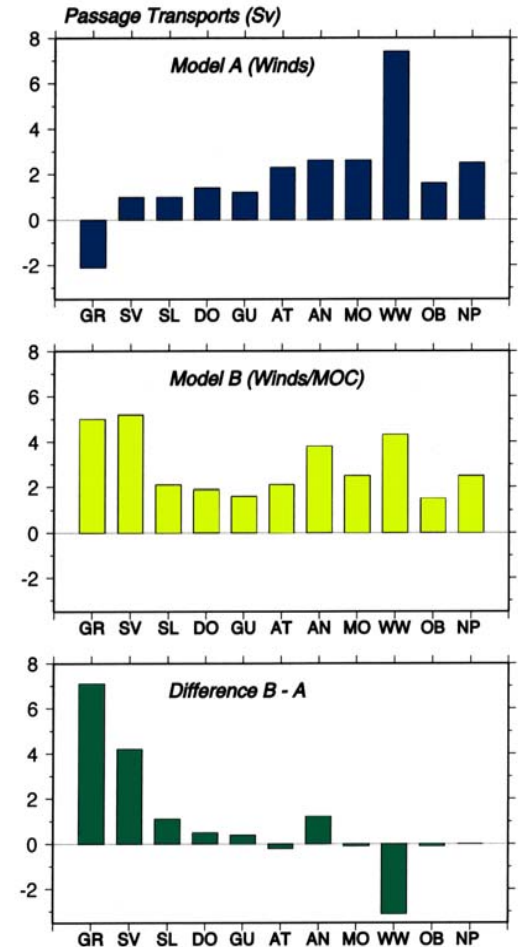
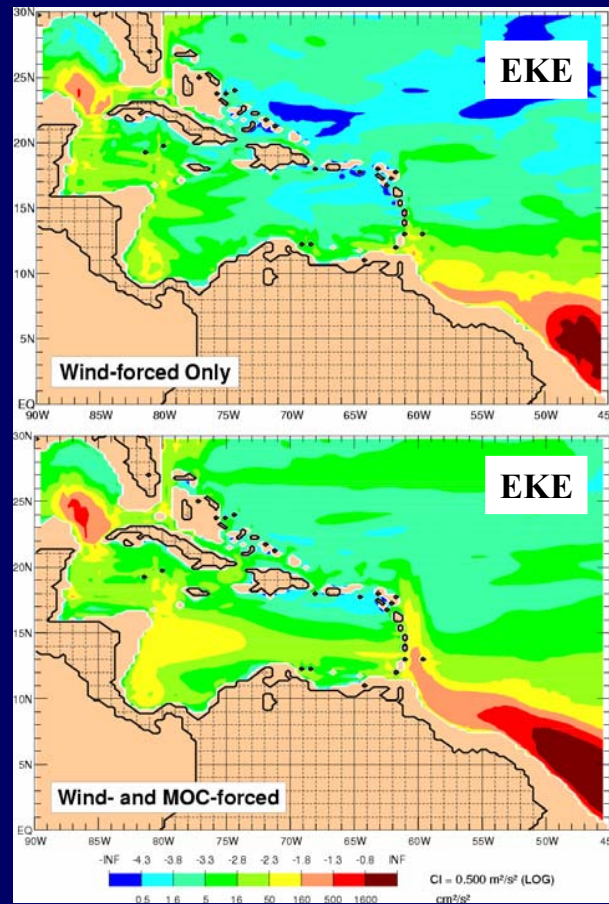
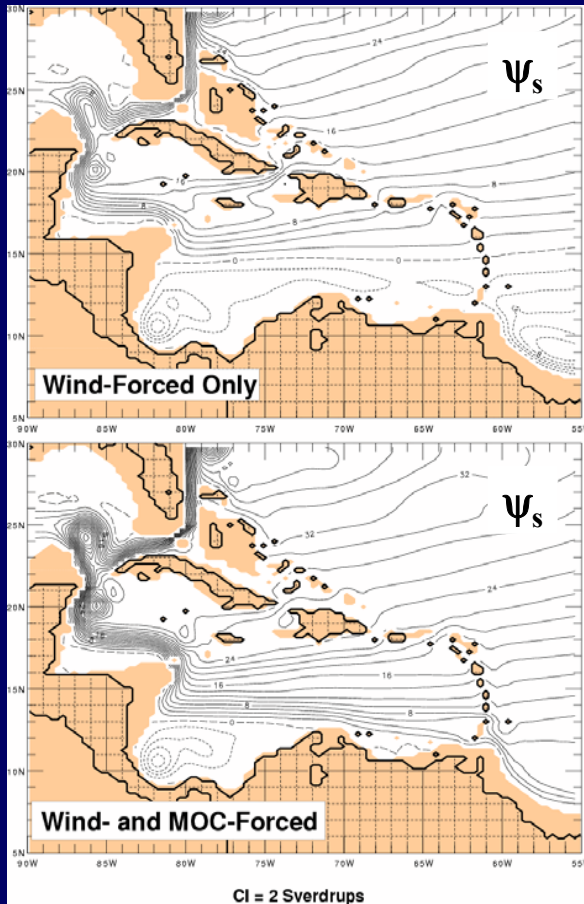
An intradecadal anomaly is confined to the Caribbean in a 1/2° linear simulation (bottom panel), but in a 1/4° nonlinear simulation the anomaly is propagated all the way into the western Gulf of Mexico via eddies from the Caribbean (top panel).



1985-1987 mean minus 1981-1991 mean sea surface height. Both the 1/2° 1.5-layer linear and the 1/4° 5.5-layer nonlinear global reduced gravity model simulations were forced by daily ECMWF 1000mb winds with the long-term mean replaced by the Hellerman and Rosenstein (1983; JPO) annual mean.

Impact of the Meridional Overturning Cell

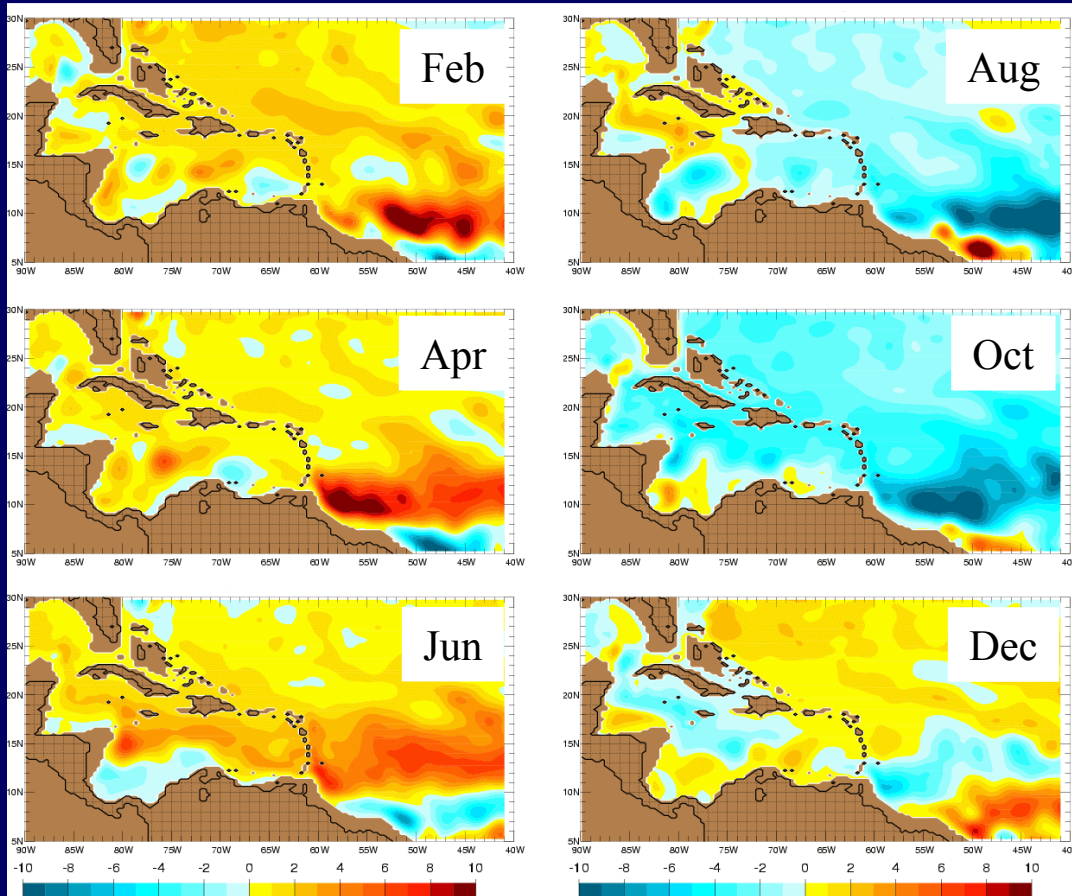
1/4°, Nonlinear, 6-Layer N. Atlantic NLOM



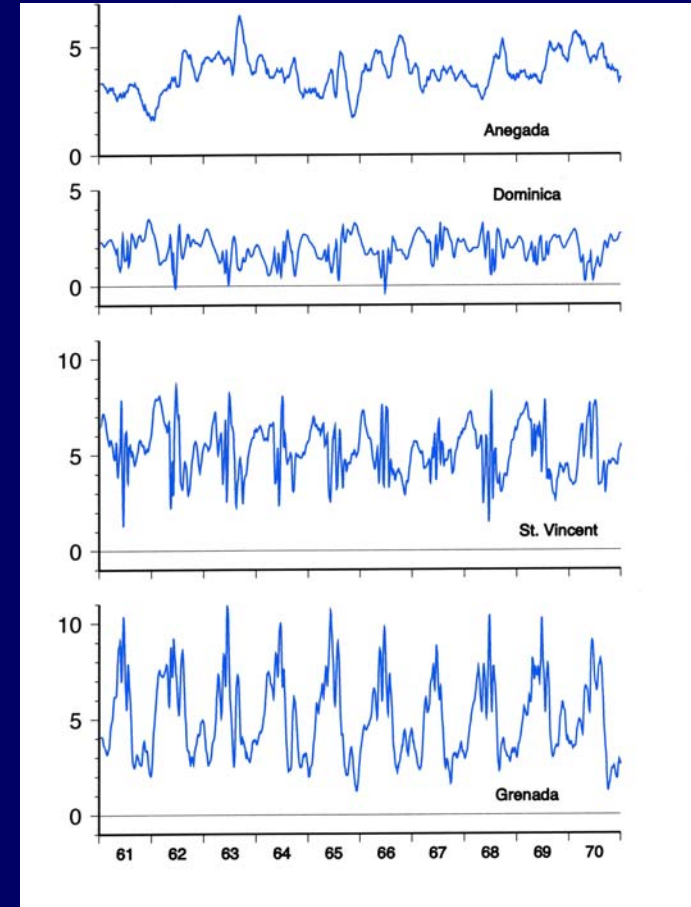
Johns *et al.*, DSR, 2002

Baroclinic Circulation Response to Seasonal Wind Forcing

1/4°, Nonlinear, 6-Layer N. Atlantic NLOM

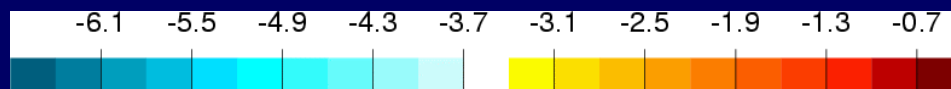
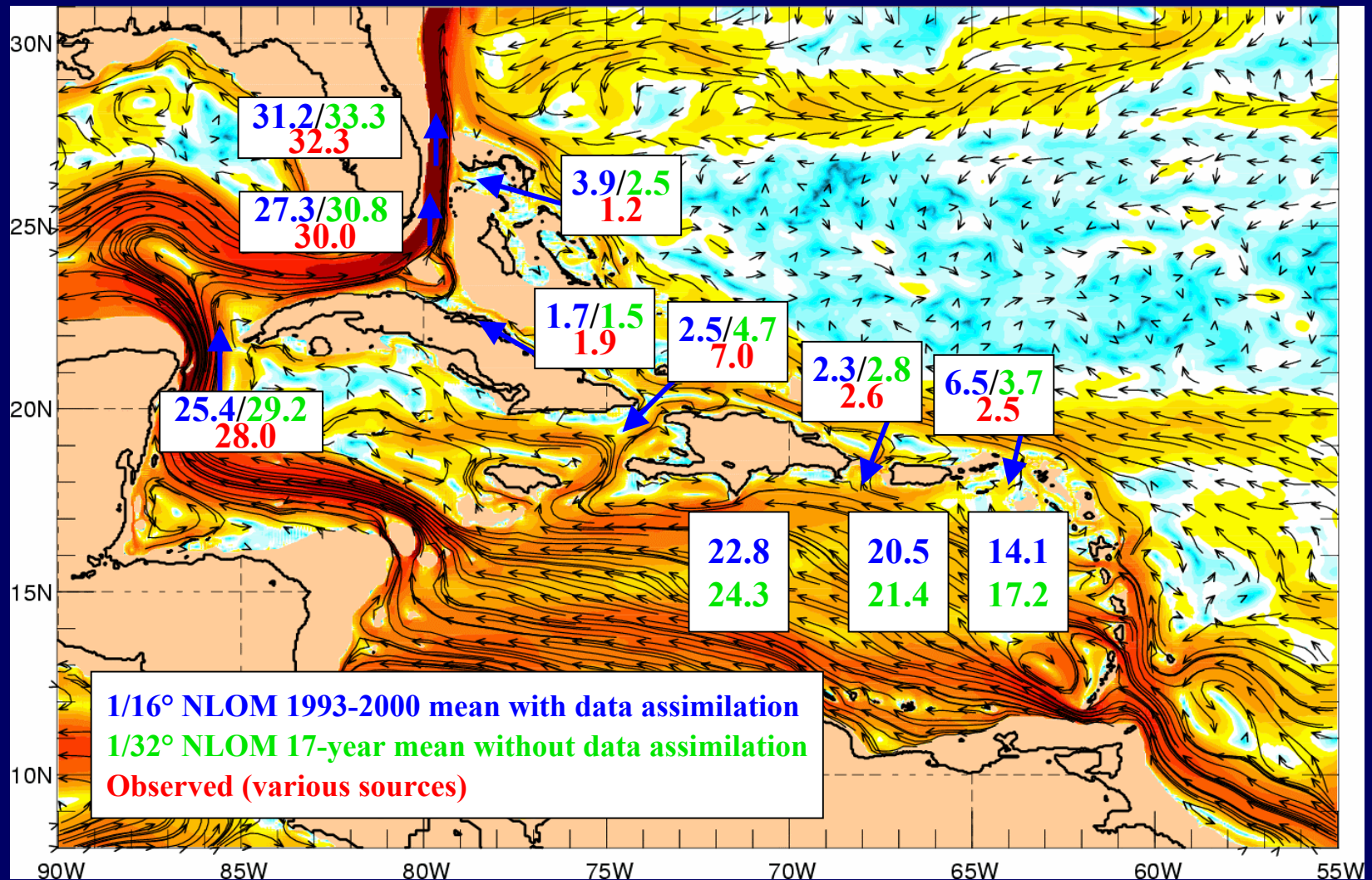


Streamfunction Anomaly (10 year mean)



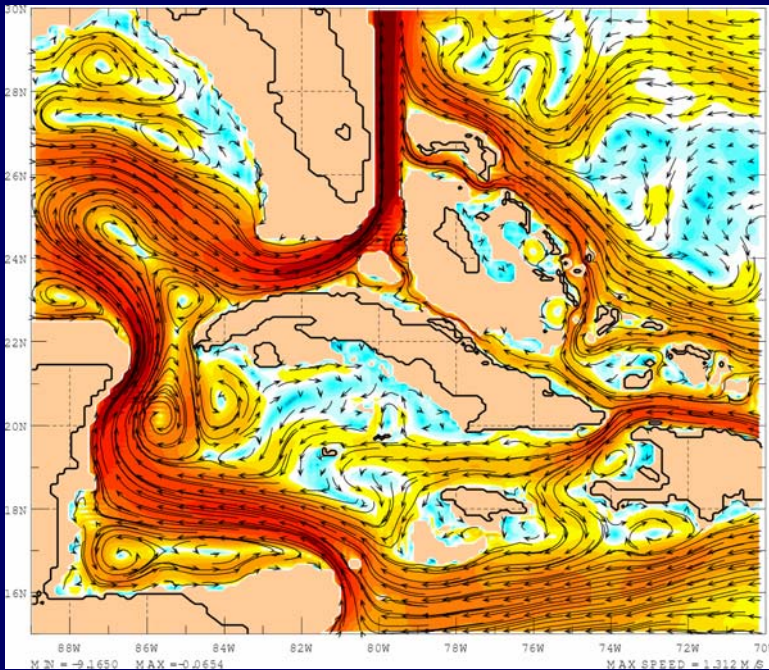
Passage Transports (Sv)

Comparison of Observed and NLOM Annual Mean Transports (Sv) Through The Intra-Americas Sea

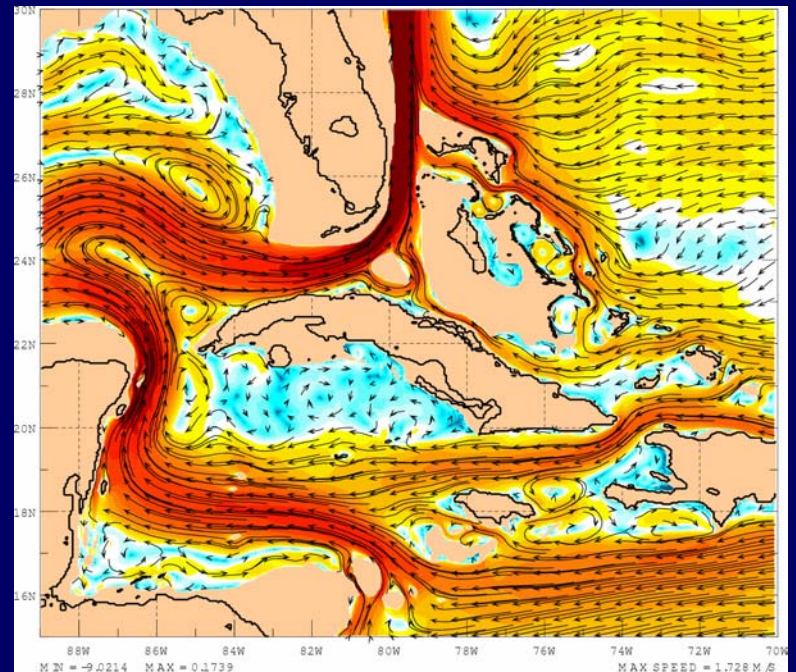


CI = 0.300 m² s⁻² (LOG)

Impact of Model Grid Resolution (Coastline Geometry)



1/16° Global NLOM

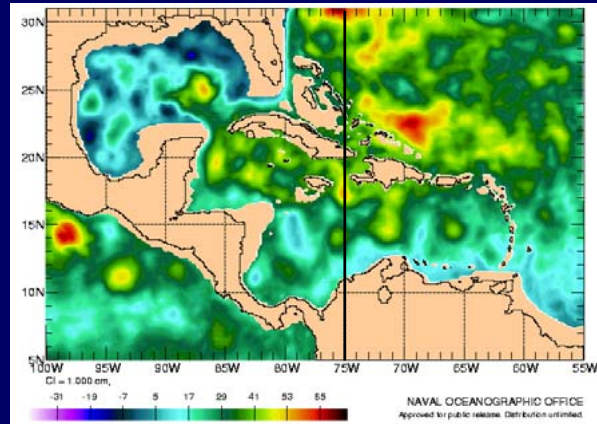


1/32° Global NLOM

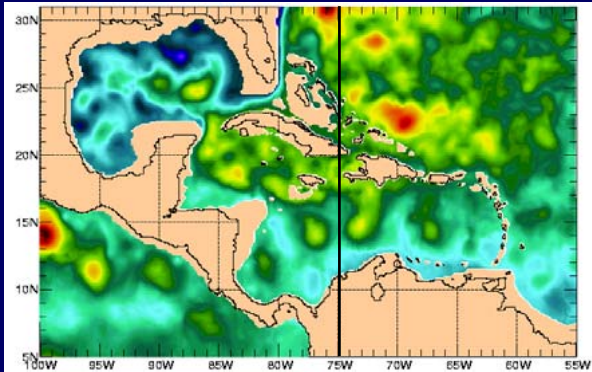
Mean Layer 2 Currents



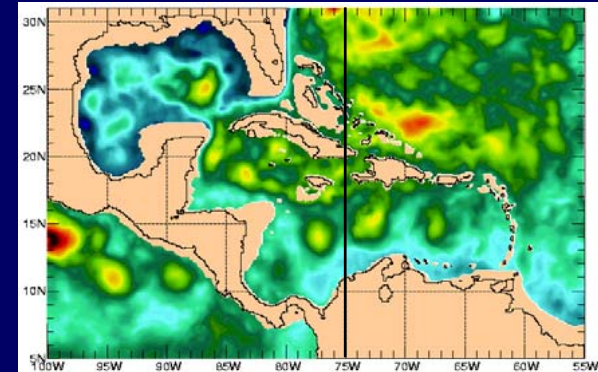
Real-time 1/16° Global NLOM - Intra-Americas Sea Region Forecast Verification



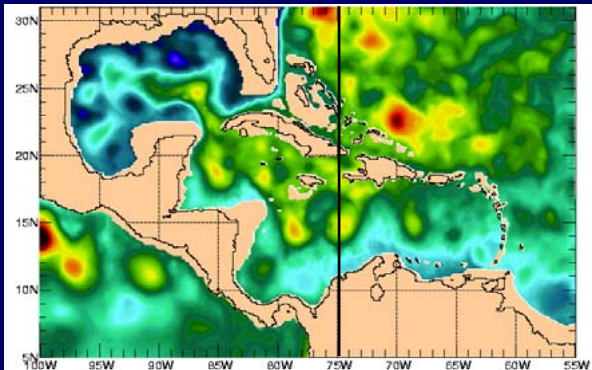
NLOM SSH analysis January 3, 2001



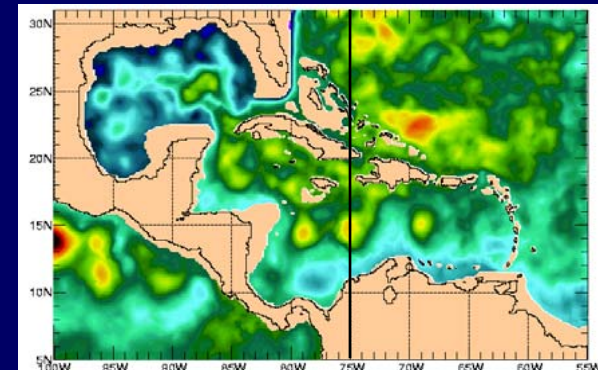
15-day NLOM SSH forecast valid January 18, 2001



NLOM SSH analysis valid January 18, 2000

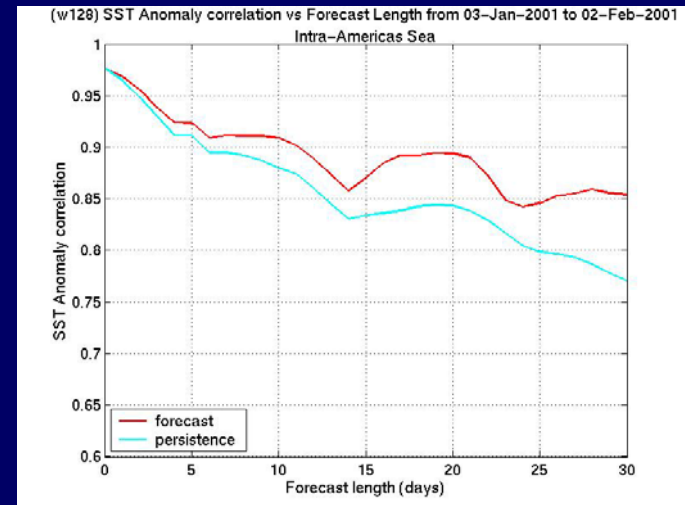
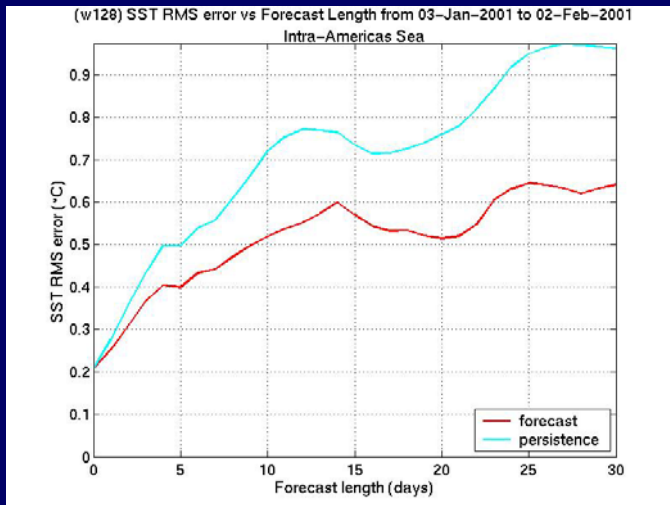
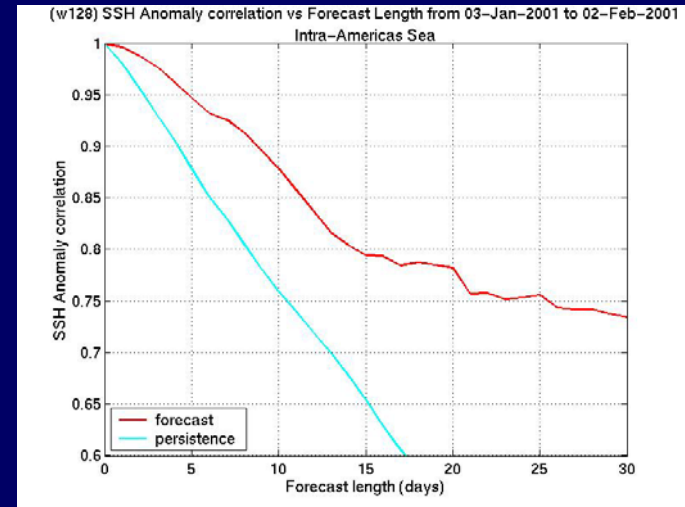
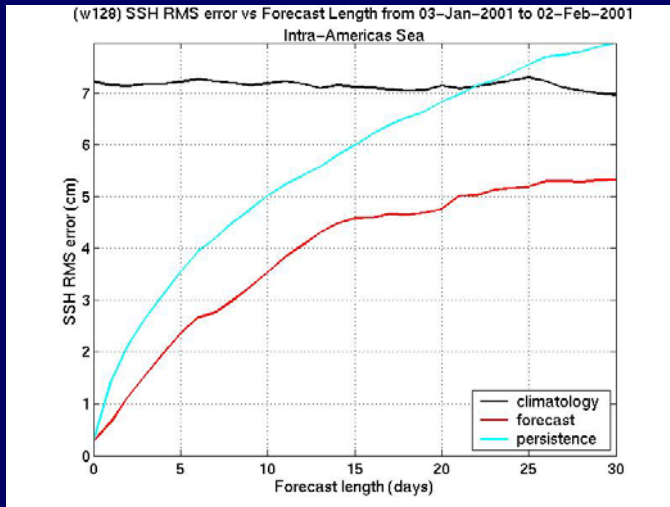


30-day NLOM SSH forecast valid February 2, 2001



NLOM SSH analysis valid February 2, 2000

Real-time 1/16° Global NLOM - Intra-Americas Sea Region Forecast Skill Assessment



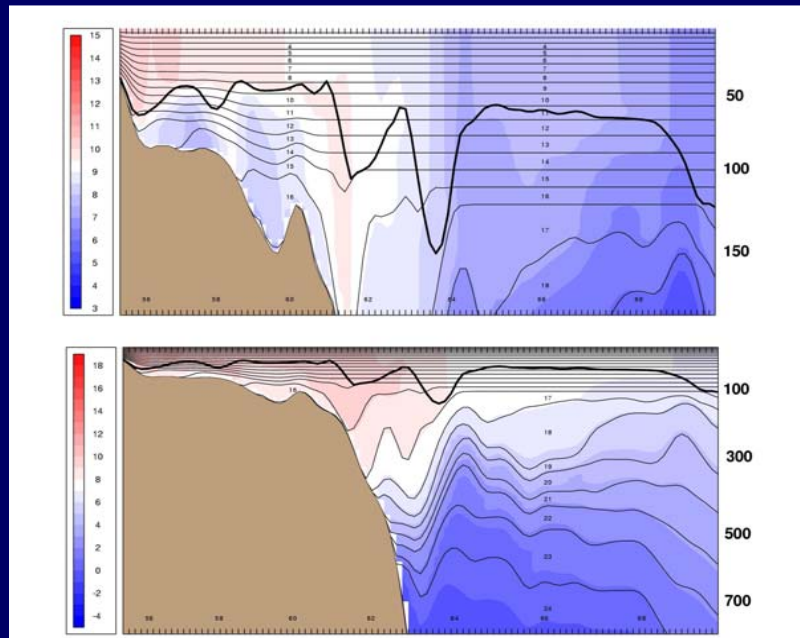
HYbrid Coordinate Ocean Model (HYCOM)

2nd Generation Operational Global Navy Model

Generalized vertical coordinate

Dynamic in space and time

Dynamically smooth transition via the layered continuity equation



Isopycnal

Open, stratified ocean

Terrain-following (σ)

Shallow coastal regions

Z-level

Near surface (mixed layer)

Unstratified regions

Toward a Global Operational HYCOM

Long Term Goal

High-resolution global HYCOM for Navy applications with data Assimilation, including the Arctic and shallow water .

Approach

Overall: Basin & regional test beds for modeling, nesting, data assimilation schemes from simple to advanced – Pacific, JES, IAS.

IAS: Off-line, one-way nesting of the domain; numerous simulations at $.08^\circ$; a few simulations at $.04^\circ$; high-resolution test bed for advanced data assimilation techniques; at target resolution of global HYCOM.

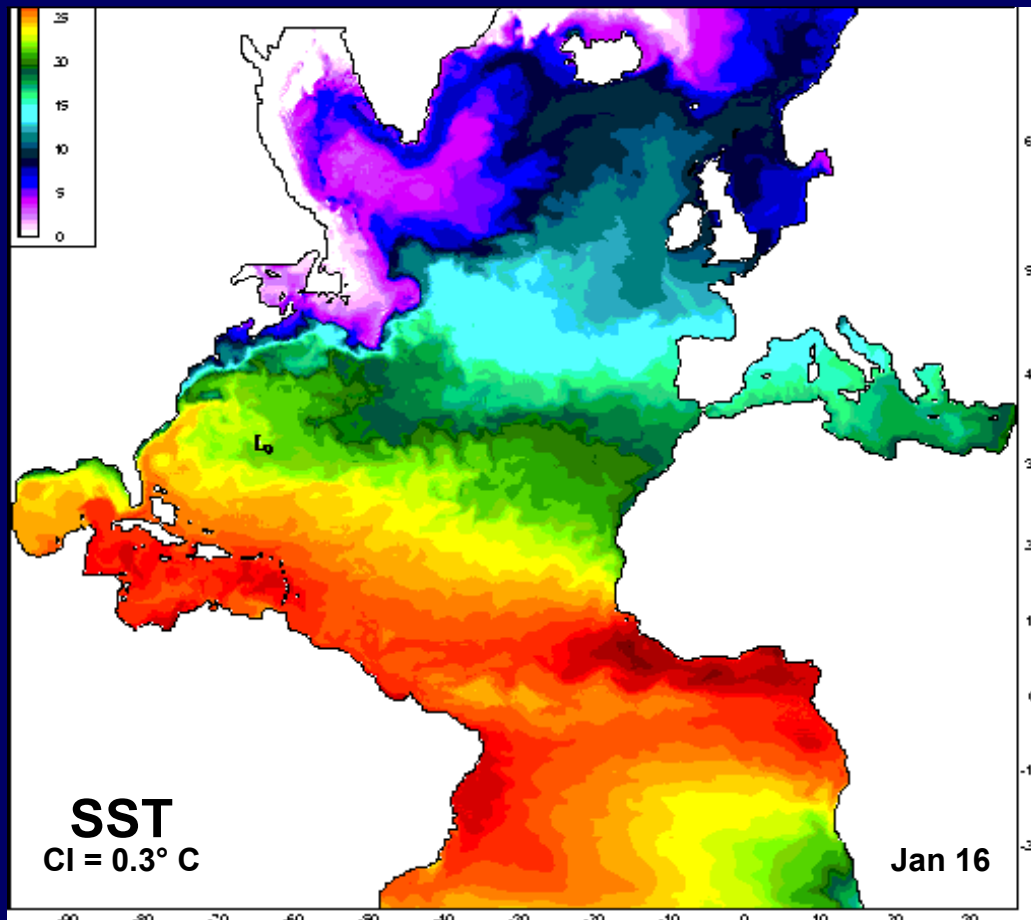
Objective

Overall: Development & evaluation of HYCOM as next-generation model for eddy-resolving global ocean prediction.

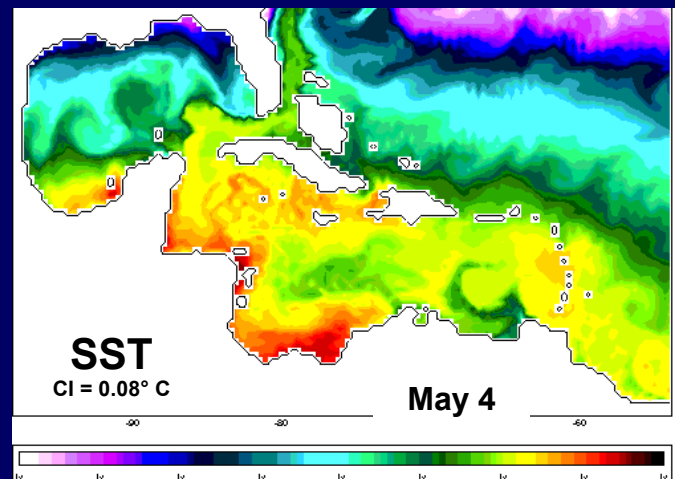
IAS: Development & evaluation of nesting capability for domains with (a) extensive open boundaries in the open ocean and (b) baroclinic flows through the open boundaries.

HYCOM Nesting Applied to IAS

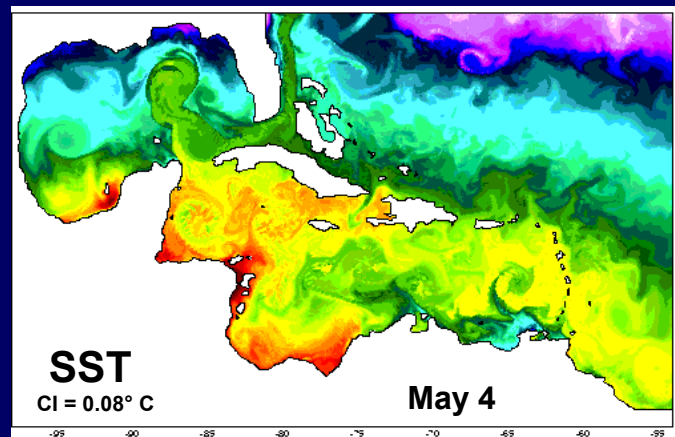
North Atlantic, 0.32°



North Atlantic, 0.32°



Intra-Americas Sea, 0.08°



Forced by 1979-1993 Monthly Mean ECMWF Reanalysis 10 m winds and boundary conditions from the 0.32° North Atlantic HYCOM

INTRA-AMERICAS SEA HYCOM

Permits use of sigma coordinates over shelf - Variable width in IAS

0.08° (7.6 km at mid-domain) - 551 x 346

0.04° (3.8 km at mid-domain) - 1101 x 691

5°N-31°N,98°W-54°W

22 layers

Done: 0.08° Nested inside 0.32° Atlantic model

Current Effort:

0.08° Nested inside 0.08° Atlantic model

To evaluate the nesting scheme

0.04° Nested inside 0.08° Atlantic model

HYCOM Ocean Boundary Conditions

Two distinct sets of boundary conditions:

a) Relaxation to T/S/p/V in a buffer zone

Available only from 3-D archive files

b) Depth-averaged flow

Available from both 3-D and surface archive files

One-way (off-line) nesting:

3-D and barotropic from a coarser enclosing model

**3-D from an enclosing model and barotropic via
ports**

3-D T/S/p/V

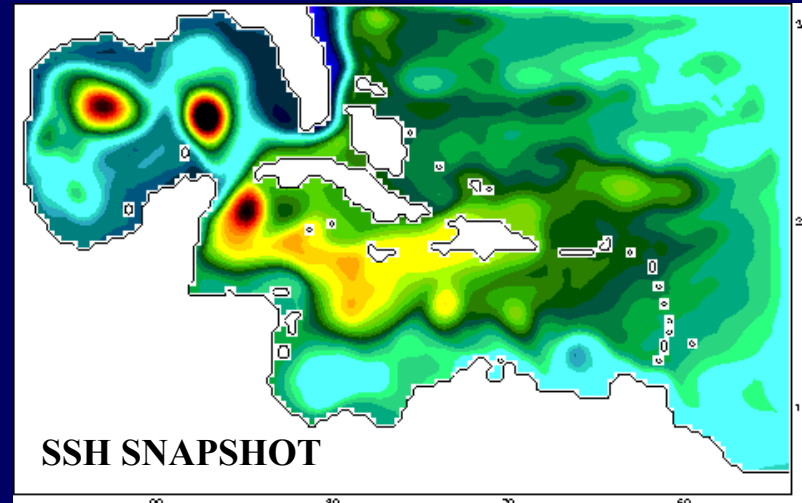
Nesting + relaxation (e.g.rivers)

Different relaxation masks

REALISTIC BOUNDARY CONDITIONS IMPORTANT

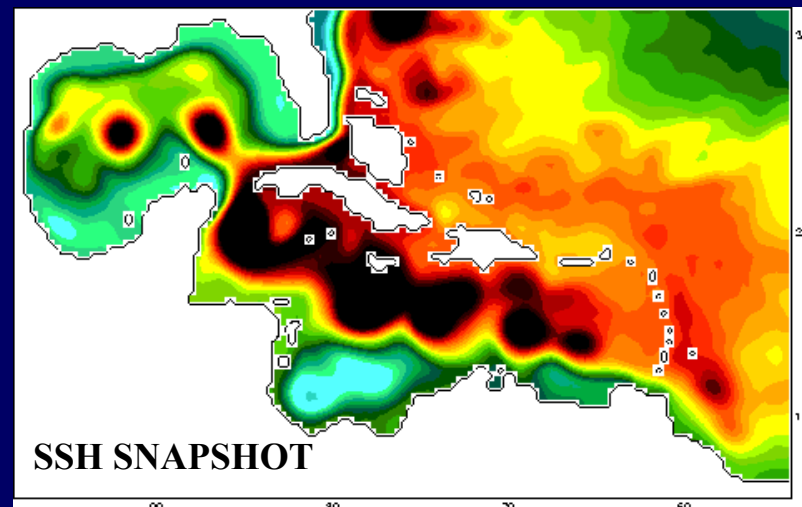
0.32° IAS-HYCOM

COADS MONTHLY SURFACE FORCING,
RELAXATION TO MODAS
CLIMATOLOGY AT N & E BOUNDARIES
AND 51 SV BAROTROPIC INFLOW
(N & E BNDRY), 10 SV OUT AT SE BNDRY
AND
41 SV OUT AT US COAST

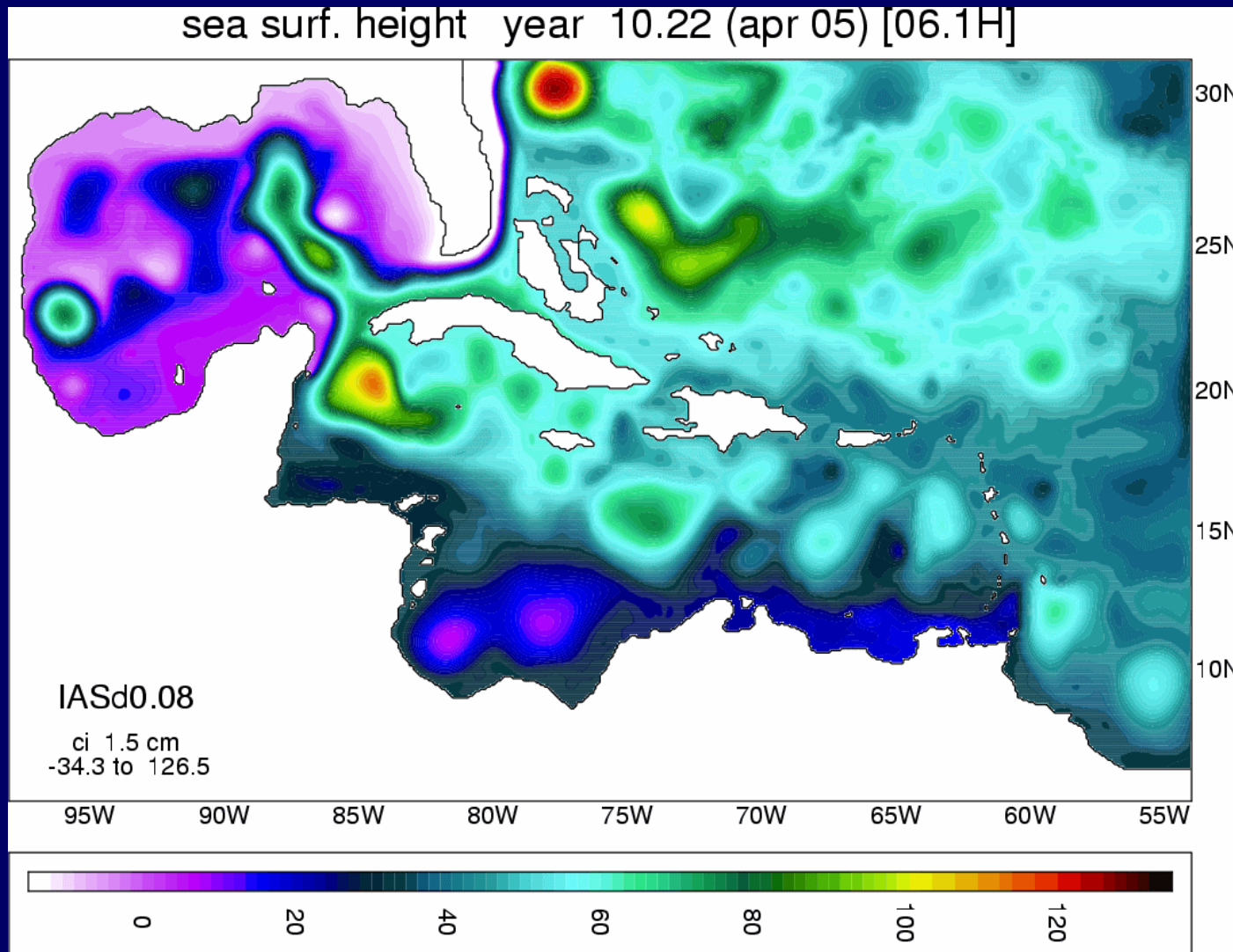


IAS REGION OF 0.32° ATLANTIC-HYCOM

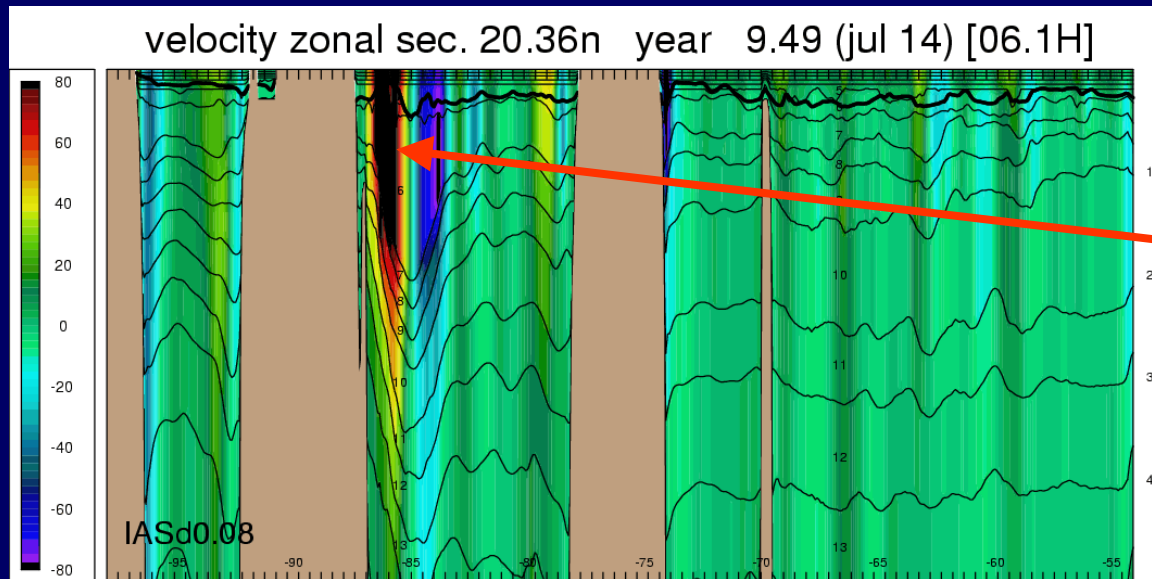
1979-1993 ECMWF REANALYSIS
MONTHLY MEAN SURFACE FORCING
AND RELAXATION TO MODAS
CLIMATOLOGY AT NORTHERN (70°N)
AND
SOUTHERN (28°S) BOUNDARIES



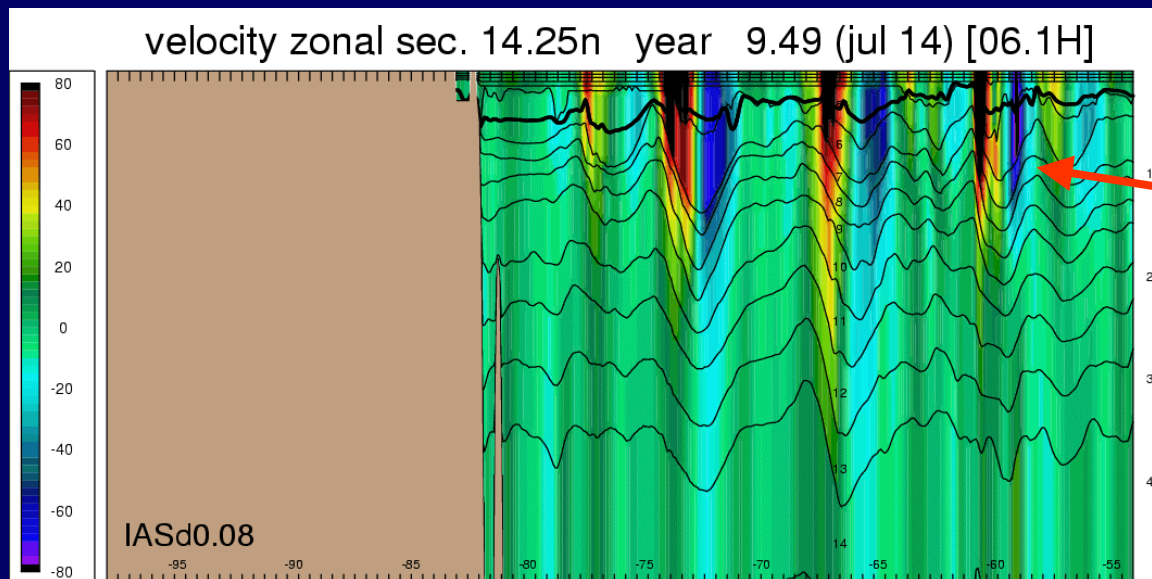
0.08° INTRA-AMERICAS SEA HYCOM



0.08° INTRA-AMERICAS SEA HYCOM

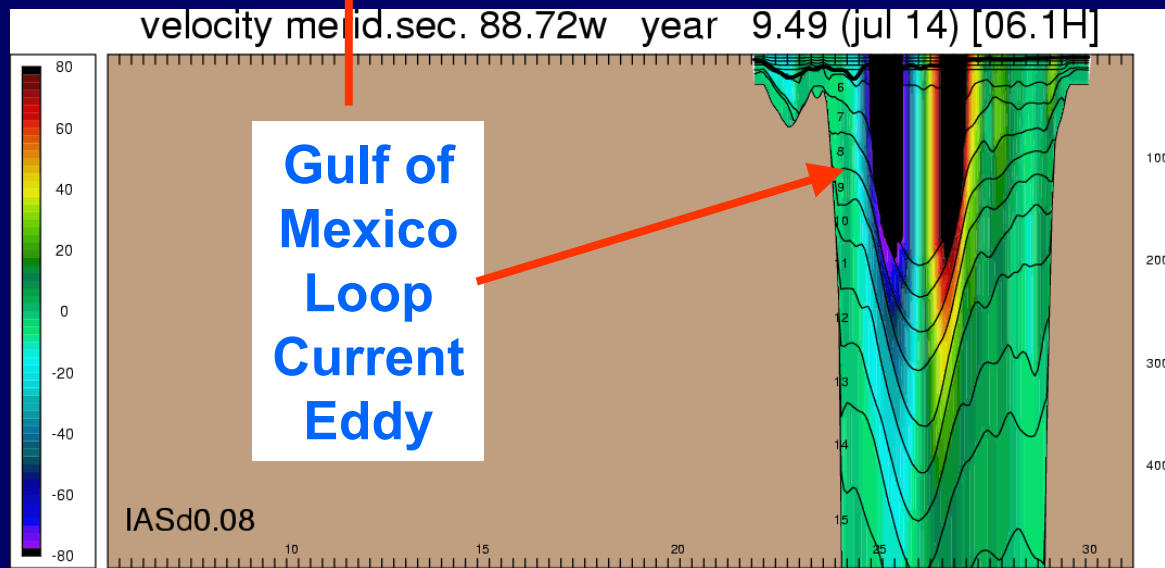
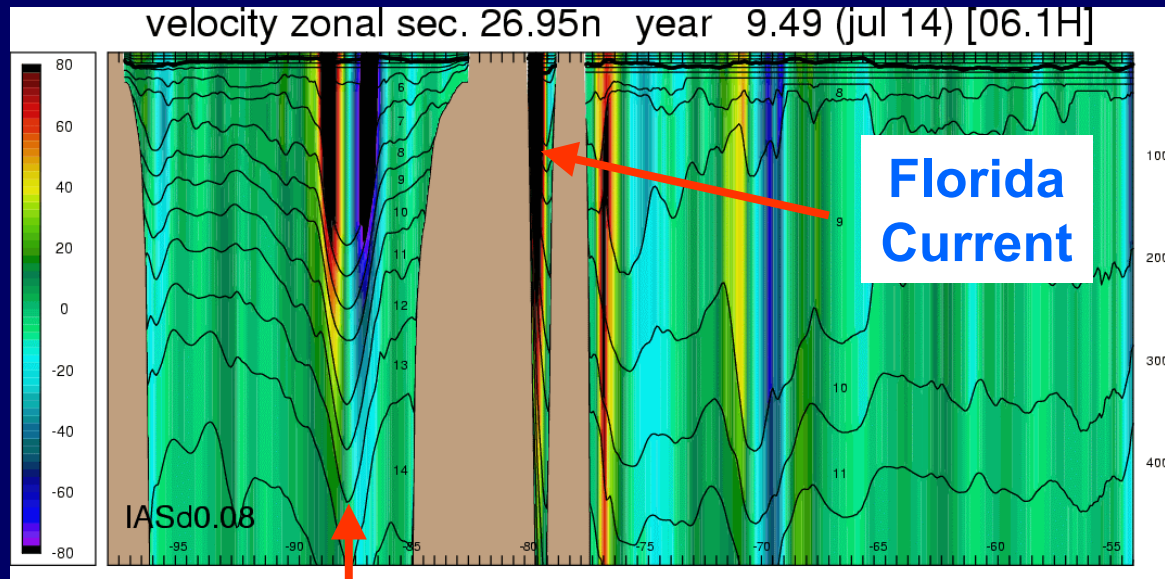


**Yucatan
Current**



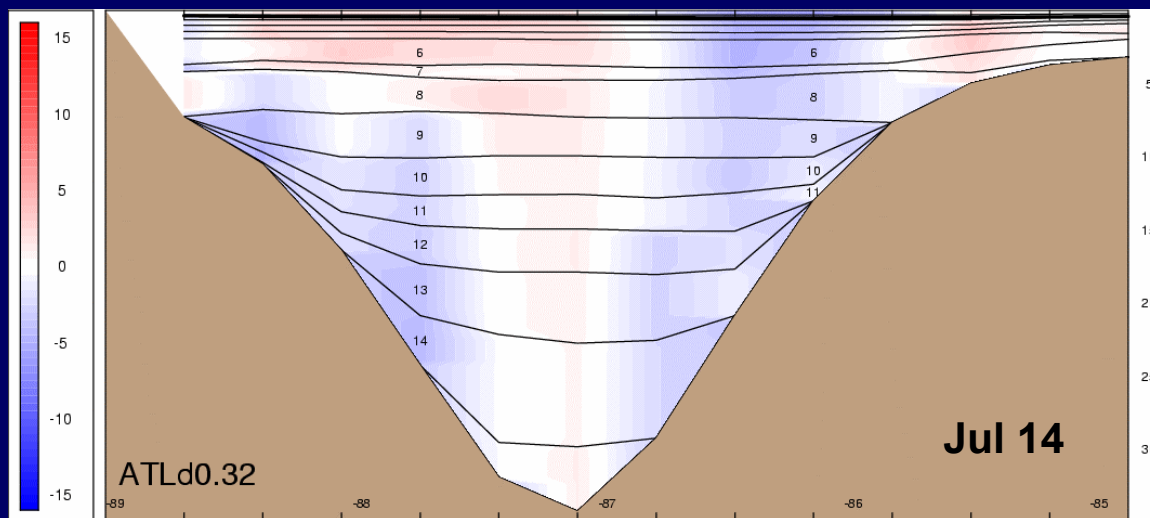
**Sequence of
Caribbean
Eddies**

0.08° INTRA-AMERICAS SEA IAS-HYCOM

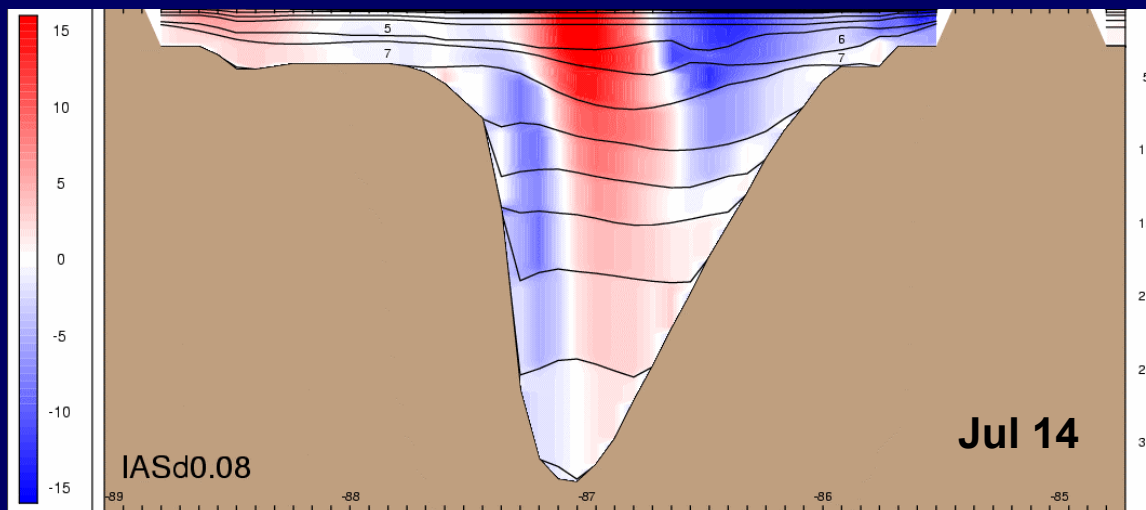


Meridional Velocity, De Soto Canyon, Gulf of Mexico

0.32° North Atlantic HYCOM



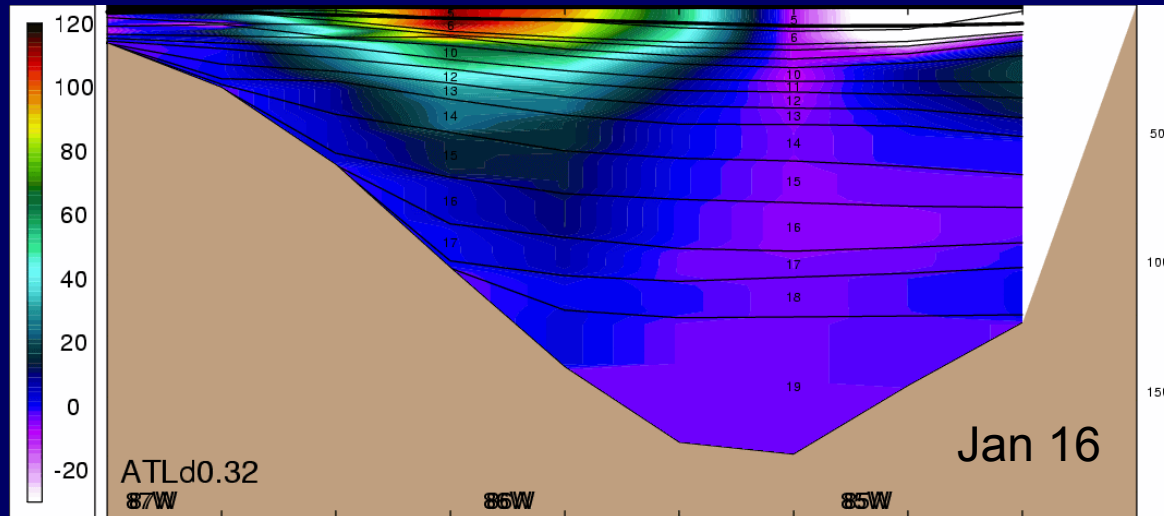
0.08° Intra-Americas Sea HYCOM



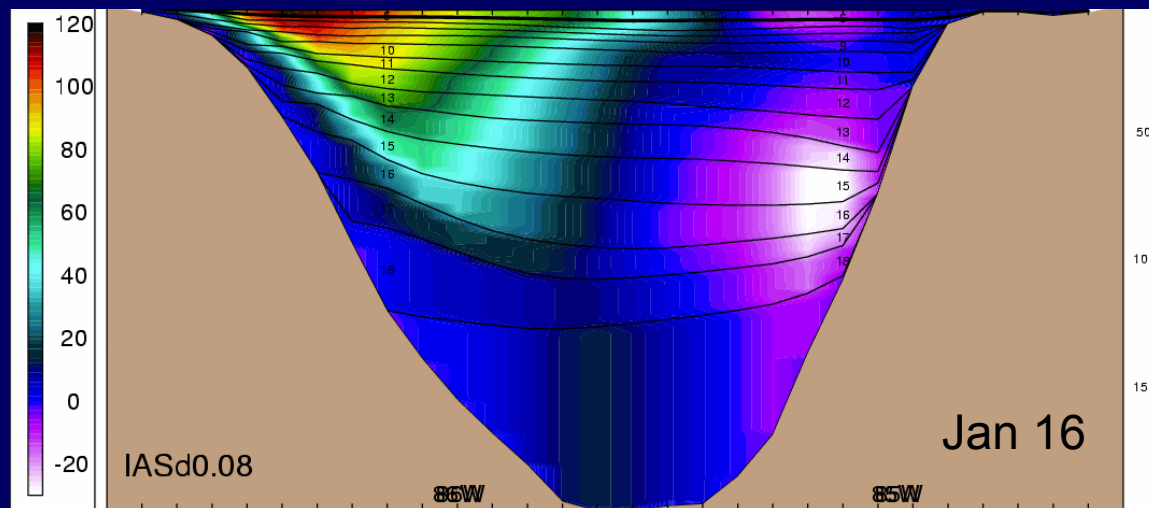
Forced by 1979-1993 Monthly Mean ECMWF Reanalysis 10 m winds and boundary conditions from the 0.32° North Atlantic HYCOM

Meridional Velocity, Yucatan Channel

0.32° North Atlantic HYCOM

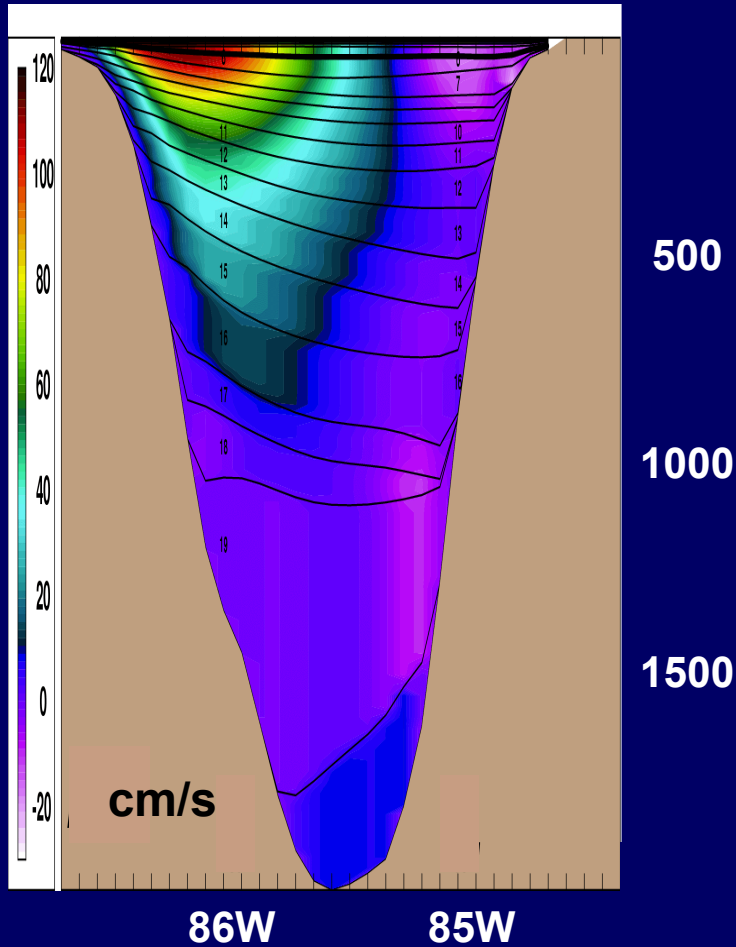


0.08° Intra-Americas Sea HYCOM

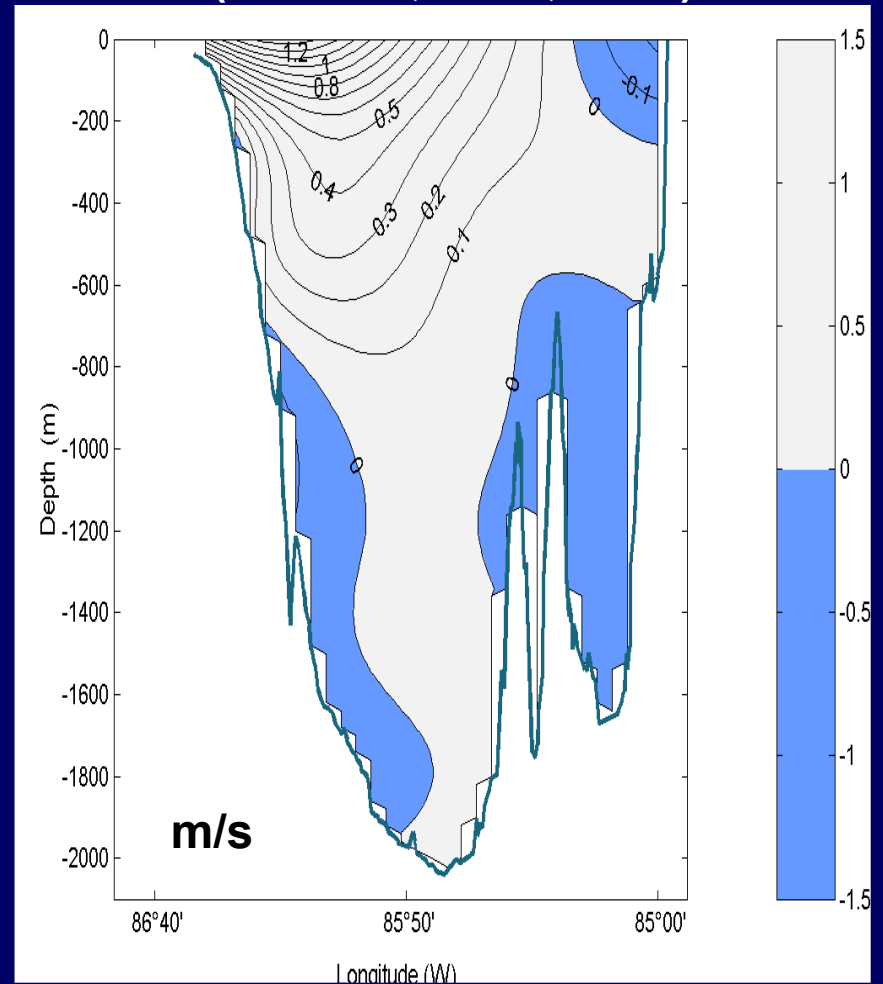


Yucatan Channel Normal Velocity

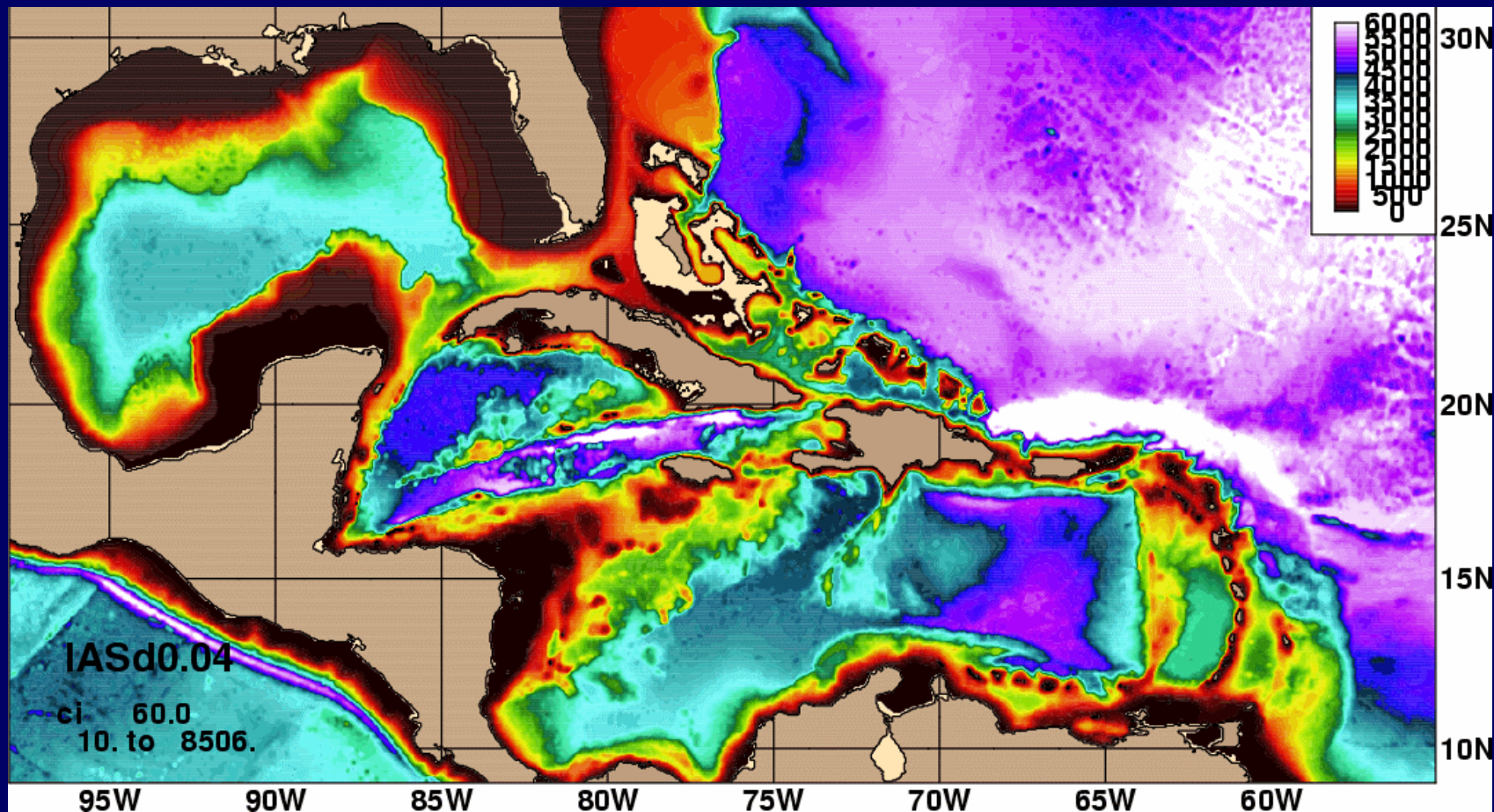
0.08° ATL HYCOM 1-Year Mean



Observed Mean 8/1999-6/2000
(Abascal, et. al, 2001)



0.04° IAS-HYCOM Topography



Source: global NRL DBDB2 (2' x 2') with modifications in targeted areas after interpolation to model grid
Coastline: 5 m isobath. Minimum depth: 10 m